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Projections of National Health Expenditures: Methodology and Model Specification

The Office of the Actuary (OACT) in the Centers for Medicare & Medicaid Services (CMS) annually produces short-term (11 years) projections of health care spending for categories within the National Health Expenditure Accounts (NHEA). When these projections are released, detailed tables appear on our website and a paper is published in Health Affairs. [1] The NHEA track health spending by source of funds (for example, private, Medicare, Medicaid) and by type of service (hospital, physician, pharmaceuticals, etc.).

To produce projections for total National Health Expenditures (NHE), OACT combines projections for Medicare and Medicaid spending (based on actuarial techniques) with projections for private health spending (based on a multi-equation structural econometric model, hereafter referred to as the NHE Projection Model). The NHE Projection Model attempts to capture the causal relationships between major macroeconomic variables and private health spending, as well as interactions among major causal variables within the health sector. The macroeconomic and demographic outlook from the 2009 Trustees Report and the projections of Medicare and Medicaid spending produced by OACT are exogenous inputs into the model.

Projections are inherently subject to uncertainty. The models are estimated based on historical trends and relationships in health spending; any structural break in these relationships is generally unpredictable. These projections also rely on assumptions about macroeconomic conditions and health sector parameters and their relationship to health care spending, with the degree of uncertainty increasing along with the projection horizon. Therefore, we qualify our projections subject to these uncertainties and how they might affect our results.

The methodology and specification for the NHE Projection Model are presented below. The discussion is organized in the following sections:

[1] Truffer C. et al., "Health Spending Projections through 2019: The Recession's Impact Continues," *Health Affairs* 29, no. 3 (2010): 1-9 (published online 4 February 2010)

I. Data Sources

Health Expenditures

All historical data for health expenditures are derived from the NHEA compiled by OACT. The NHEA is a national level matrix of health spending data by type of service and source of funding. Information on the methodology used in producing these historical estimates can be found at http://www.cms.hhs.gov/NationalHealthExpendData/downloads/dsm-08.pdf. Types of services and sources of funding projected in our model are listed below.

Types of Services

National Health Expenditures
- Health Services and Supplies
  - Personal Health Care
    - Hospital Care
    - Professional Services
      - Physician and Clinical Services
      - Other Professional Services
    - Dental Services
    - Other Personal Health Care
    - Nursing Home and Home Health
      - Nursing Home Care
      - Home Health
    - Retail Outlet Sales of Medical Products
      - Prescription Drugs
      - Durable Medical Equipment
      - Nondurable Medical Products
  - Program Administration and Net Cost of Private Health Insurance
  - Government Public Health Activities
- Investment
  - Structures
  - Equipment
  - Research

Sources of Funding

National Health Expenditures
- Private
  - Consumer Out-of-Pocket
  - Private Health Insurance
  - Other Private
- Public
  - Federal
    - Medicare
    - Medicaid
    - Other Federal
  - State and Local
    - Medicaid
    - Other State and Local

Medical Price Indexes

Data sources for medical prices are consistent with those used in the NHEA. For most types of services, price indexes are based on the Consumer Price Indexes (CPI) published by the Bureau of Labor Statistics (BLS). However, for nursing home services we use input price indexes compiled by CMS, and for hospital services we use a Producer Price Index (PPI) from BLS. For inpatient hospital services in the period from 1993 forward, the NHEA uses the PPI for hospital services introduced in December 1992. To obtain a measure closer to a transaction price, the PPI uses a methodology that attempts to capture discounts and redefines the "items" included in the index. For years prior to 1993, OACT estimated a transaction price measure based on an adjusted version of the CPI for hospital and related services.

For nursing home services, for which no separate price index is available for the time period required, we use input price indexes (IPIs) developed by OACT to track input costs incurred by these providers. IPIs are used as a proxy for output prices based on the assumption that input costs will be a major determinant of output prices. Use of the IPI implies that we did not capture the effects on output prices of productivity change and fluctuating profit margins.

Our price measure for total personal health care spending is a chain-weighted deflator based on the indexes in the table below, with the weight for each index set equal to the share of personal health care expenditures accounted for by that type of service.

Derivation of the personal health care expenditure chain-type annual-weighted price index

Industry/Commodity or Service	Price proxy	2008 weight
Personal health care		100.0
Hospital care	PPI, hospitals*	36.8
Physician and clinical services	CPI, physician services	25.4
Other professional services	CPI, other professional services	3.4
Dental services	CPI, dental services	5.2
Home health care	CPI, professional services	3.3
Other personal health care	CPI, medical care	3.5
Nursing home care	National Nursing Home Input Price Index	7.1
Prescription drugs	CPI, prescription drugs and medical supplies	12.0
Other non-durable medical products	CPI, internal & respiratory over-the-counter drugs	2.0
Durable medical equipment	CPI, eyeglasses and eye care	1.4

*Producer Price Index for hospitals, U.S. Department of Labor, Bureau of Labor Statistics. Used beginning in 1994 and scaled to 100.0 in 2000. Indexes for 1960-93 are based on a CMS developed output or transaction price index.

Insurance Coverage Data

Private health insurance enrollment data are compiled by OACT using a combination of the National Health Interview Survey (NHIS) and the Current Population Survey (CPS). Presently, the insured population is benchmarked to the 1997 NHIS and is then escalated using the change in the insured population from the CPS. The National Health Expenditure Accounts team is currently in the benchmark process of evaluating data sources to improve the accuracy of the private health insurance enrollment estimate.

Within our model for private PHC spending, shifts in coverage between private health insurance, Medicare, and Medicaid are captured through the effects of public spending growth. Within our model for private health insurance enrollment, we take trends in Medicaid and Medicare enrollment as exogenous inputs, based on the 2009 Trustees Report with updates for recent data. Growth in enrollment in private health insurance per capita (PHI) is projected as a function of macroeconomic indicators, which capture the loss of coverage due to rising unemployment and slowing real income growth. Private health insurance enrollment also has a strong link to Medicaid enrollment. As a greater share of the working-age population becomes eligible for Medicaid, declines in private health insurance enrollment are partially offset by increases in Medicaid enrollment. The variables in our current model are lagged values of two economic indicators;

- Civilian unemployment rate. Increased unemployment reduces PHI enrollment.
- Real disposable personal income (DPI). The model includes a polynomial distributed lag on growth in DPI. A four-year lag is included, but the current year and previous year's income growth account for almost all of the impact.

Medicaid enrollment is not directly controlled for within the econometric model. However, changes in Medicaid enrollment are highly correlated with changes in the unemployment rate (correlation = 0.6) so that the relationship between private health insurance and Medicaid enrollment is captured indirectly.

The projection of private health insurance enrollment is linked to projections of private PHC spending growth, and to projections of the share of private spending accounted for by PHC. Both private spending

growth and private health insurance enrollment are driven primarily by macroeconomic trends, but the model for private health insurance enrollment places greater emphasis on labor market conditions. Trends in private spending per enrollee and private health insurance spending per enrollee are monitored and adjusted during the projections process.

Total enrollment in Health Maintenance Organizations (HMOs) is based on data from Interstudy.[2] Data for Medicare and Medicaid HMO enrollment are compiled by OACT from CMS program data. Private enrollment is estimated as a residual after subtracting Medicare and Medicaid enrollment from total enrollment.

Exogenous Projections

Projections for macroeconomic variables, such as economic growth and economy-wide inflation, and demographic variables, such as the age composition of the population, are derived from the annual projections of the Board of Trustees for OASDI (Federal Old-Age, Survivors, and Disability Insurance). These projections are produced annually by the Social Security Administration (SSA).[3]

A projection for disposable personal income (DPI) consistent with the economic assumptions from the 2009 Medicare Trustees Report is generated using the University of Maryland Long Term Interindustry Forecasting Tool (LIFT). The relationship between DPI and GDP is influenced by fluctuations in taxes and government transfer payments, depreciation of capital stock, and retained earnings and transfer payments of private business.

The Board of Trustees for Medicare reports annually to the Congress on the actuarial status of the Hospital Insurance and Supplementary Medical Insurance Trust Funds.[4] These projections, as well as the Medicaid and State Children's Health Insurance Program (SCHIP) projections, are produced by OACT and are also consistent with macroeconomic and demographic assumptions included in the OASDI Trustees Report.

Projections for input price indexes in each sector are based on projections from IHS Global Insight, Inc. Since these projections are generated conditional on macroeconomic assumptions for aggregate wage and price growth that differ from those incorporated in the OASDI Trustees report, price and wage proxies proxy included in these indexes are adjusted for consistency with OASDI. This adjustment is based on an adjustment for each index proxy based on smoothed ratios of SSA projections for economy wide price and wage concepts (CPI-all items and total wage compensation per employee) to projections for the comparable variables as projected by IHS Global Insight, Inc.

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[2] HMO enrollment includes enrollees in both traditional HMOs and point-of-service (POS) plans through: group/commercial plans, Medicare, Medicaid, the Federal Employees Health Benefits Program, direct pay plans, and unidentified HMO products. InterStudy Publications, *The InterStudy Competitive Edge, Part II: HMO Industry Reports*, 1993-2006.

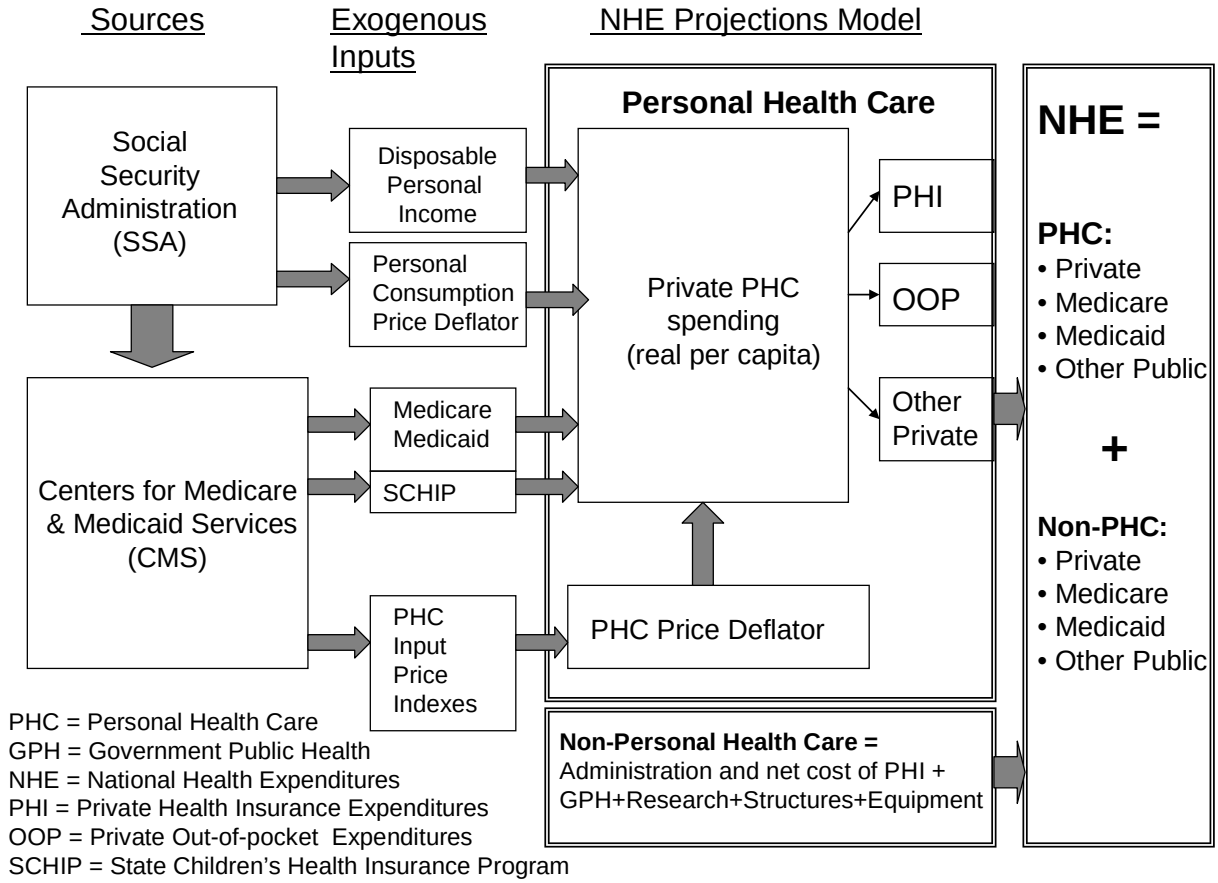
[3] Board of Trustees, Federal Old-Age and Survivors Insurance and Disability Trust Funds, *The 2009 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds*, 12 May 2009, http://www.socialsecurity.gov/OACT/TR/2009/tr09.pdf (accessed 26 January 2010).

[4] Board of Trustees, *2009 Annual Report of the Boards of Trustees of the Federal Hospital Insurance Trust and Federal Supplementary Medical Insurance Trust Funds*, 12 May 2009, http://www.cms.hhs.gov/ReportsTrustFunds/downloads/tr2009.pdf (accessed 26 January 2010).

The latest release of the NHE projections was produced in the fall of 2009. This forecast incorporates projections from the 2009 Trustees Reports issued in the spring of 2009, updated to reflect additional macroeconomic, Medicare, and Medicaid data available through December, 2009.[5]

II. Model Specification

The structure of the NHE Projection Model for private health spending is an econometric model that is estimated based on the historical National Health Expenditures. The structure and parameters of the model draw on standard economic theory and the health economics literature. The diagram below provides a schematic view of the aggregate health sector within the NHE Projections Model and shows the linkages among the data sources, exogenous data, the personal health care (PHC) model, the non-PHC output, and the aggregate NHE projections.



[5] The updated macroeconomic forecast comes from the December 2009 publication of the Blue Chip Economic Indicators, a survey of 50 of the top forecasts by different private companies and academic institutions. More information on the report is found at: http://www.aspenpublishers.com/blue-chip-publications.htm.

The NHE Projection Model is a "top-down" model. The projected growth in private personal health care (PHC) spending and medical inflation is primarily determined at the aggregate level on the basis of exogenous projections of macroeconomic variables, actuarial projections of spending for the Medicare and Medicaid programs, and health sector assumptions.

Models for spending growth and price inflation for individual types of medical services are estimated and solved separately, based on models similar in specification to the aggregate model. Model solutions for all types of services are then constrained for consistency with the aggregate spending projection.[6] Our choice of this type of model reflects our finding that the model is substantially more robust at the aggregate level.[7]

Projections of private sources of funds (private health insurance, out-of-pocket spending and other private spending) are based on econometric models for growth in real per capita spending by each source of private funding within each type of service (e.g. PHI spending on prescription drugs as a share of total spending on prescription drugs) as a function of growth in total private spending by type of service, trends in insurance coverage (growth in enrollment in PHI, Medicaid and Medicare) and in some cases, a time trend.

Spending by the private source of funds (PHI, Out-of-pocket, and Other Private) by sectors are then normalized for consistency with aggregates for both total private expenditures by sector and aggregate spending by each of the sources of funds across all types of services based on iterative proportional fitting[8].

The core of our aggregate model of PHC spending consists of two behavioral equations:[9]

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[6] See discussion of sectoral constraints under 'Types of Service.'

[7] There are several possible reasons for this finding. First, spending for the different types of services is interdependent. Conceptual and measurement issues with the data make it difficult to convincingly capture complementary and substitutive relationships across types of services. When shifts across services are believed to have occurred on a large scale, it is difficult to accurately capture the effect on patterns of growth. For example, such a shift occurred following the introduction of Medicare's prospective payment (PPS) system for most inpatient hospital services. The magnitude and timing of the impact of PPS on hospital and physician spending is not straightforward, and the selection of proxies to capture this effect is difficult. However, the manner in which such events are specified matters, since it affects the coefficients obtained on the model variables. Working with aggregate growth rates captures the net effect on health spending of factors that cause sectoral shifts. Second, data on relative prices across types of medical services are somewhat flawed for our purposes and are not always consistent across services; thus, obtaining reasonable cross-price elasticities is difficult. Third, health services tend to be purchased as bundles that incorporate types of services extending across several different sectors, while the data are not measured in such a way that we can track the behavior of the market for these linked bundles. Aggregation across all types of medical care ameliorates these problems.

[8] "Iterative proportional fitting, also known as iterative proportional scaling, is an algorithm for constructing tables of numbers satisfying certain constraints." From Speed, T.P., "Abstract: Iterative Proportional Fitting," *Encyclopedia of Biostatistics*, 15 July 2005, http://mrw.interscience.wiley.com/emrw/9780470011812/eob/article/b2a10027/current/abstract (accessed 22 February 2008).

[9] Variables are expressed as log differences (growth rates).

- Private personal health care spending (real per capita)
- Personal health care price inflation

The independent variables in our aggregate model of private personal health care spending (real per capita private PHC) are:

- Constant term
- Disposable personal income growth (less Medicare and Medicaid, real per capita) (Exogenous)
- Relative medical price inflation (PHC)[10]
  Public spending growth (PHC, real per capita) (Endogenous)
- Time trend

Projections of exogenous variables are independent of the NHE Projections model solution, while endogenous variables are projected within the model.

The models are estimated with all variables expressed in log differences (a measure of growth rate). The relationship between health spending and the causal variables in the model is assumed to be linear. This structure implies that the relationship between growth in health spending and growth in each of the independent variables is constant over time.[11] Constant coefficients on growth imply that the elasticities of demand for health care with respect to income, relative price, and public spending are constant over time. In fact, over a very long-term forecast horizon (e.g. 75 years), these relationships cannot be constant. Implications of these assumptions must therefore be evaluated in the process of projecting over a ten-year horizon.

A notable change to this year's model for private real per capita PHC spending is the inclusion of a time trend, implying a modest deceleration in health spending growth from 1970 through 2008. The estimation interval has also been lengthened (previously 1978-2007, now 1970-2008). The proximate cause for these changes is the effects of recent data revisions on the model estimation. Both the CMS estimates of PHC spending and the Bureau of Economic Analysis (BEA) historical series for disposable personal income (DPI) were revised over the past year. The revisions to DPI occurred as part of the periodic comprehensive benchmark revisions. Critically, growth in DPI was revised higher on average for the decade of the 1990s, while growth in PHC was revised downward for 2006-2007. These data revisions had the effect of accentuating a negative trend in the model residuals that has become increasingly apparent over recent years.

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[10] Relative medical price inflation has been redefined in the 2009 model. The deflator that we use to measure price inflation for all goods and services is the aggregate price deflator for all consumption expenditures. We have substituted a centered three-year moving average of this deflator for the current period value in calculating relative medical price inflation. This choice was intended to better capture the longer-term substitution effect between medical and non-medical consumption by excluding some year-to-year volatility in overall consumer prices.

[11] An important potential alternative is to estimate relationships in terms of relative levels. This option has both advantages and disadvantages. The key advantage of our model lies in its purpose as a forecasting tool that with a fairly short-term forecast horizon. Capturing relationships in terms of levels is critical to a long-term projection, but a model estimated on this basis does a poorer job explaining short-term fluctuations in growth.

With the revisions to both PHC spending and to income, the negative trend in the residuals became more significant, and was apparent both over the entire period for which data is available (1960-2008), and for the shorter estimation interval that we have used since our 2006 model revision. Experimentation with alternative options for the model included updated tests for structural change in the model and in individual coefficients. However, given updated data, and important revisions to earlier data, the trend in the model residuals showed a more steady and continuous deceleration over the estimation interval. This pattern was not well fit by the assumption of a one-time structural change in our previous model. Our choice for the current revised model incorporates a negative trend in growth for real per capita PHC relative to model variables. As the trend appeared to fit reasonably consistently across the available time period, we expanded the sample to include the decade of the 1970s. We continued to exclude the 1960s, as the inclusion of the introduction of Medicare and Medicaid programs influenced coefficients on public spending in ways that do not fit recent data well.

The interpretation of an exogenous trend in health spending growth relative to the variables in the model is not obvious. It could reflect measurement issues, omitted variables, or specification issues (such as the choice of functional form for the model). The effect of the trend is modest, implying that annual trend rate of growth could be expected to decrease by three tenths of a percentage point from 2008 through 2019. In the current projection, the effect of this model change is fully offset by an increase in the projected rate of growth in real per capita DPI, so that the net effect of these two changes for growth from 2009-2019 is close to zero .

Constant Term and Time Trend

The inclusion of an exogenous time trend effectively means that the constant in the model is changing over time; the two effects are best assessed in net terms. Since the model is expressed in terms of log differences (growth rates), the inclusion of a constant implies a (constant) exogenous deterministic trend in growth in real per capita health care spending. The addition of a (log) time trend implies that this exogenous contribution to growth decelerates over time. A common interpretation for the constant term in an equation of this form is the impact of technological change (the introduction of new medical products and techniques). However, as mentioned, there are actually a number of plausible explanations for both the additional of an exogenous trend to growth and for its tendency to decline over time; for example measurement errors are rife in estimating medical price inflation, and the estimated real per capita income effect is only a rough approximation of the actual effect on aggregate health spending growth. Omitted relevant variables are an additional possibility, as are assumptions on the functional form that represents the basic model structure (e.g. our assumption that the model is a linear function of growth rates). It is worth noting that the trend continues to be significant when the model is estimated for total aggregate PHC, rather than solely private spending. On average, the constant plus trend accounts for 0.35 percentage point of growth in real per capita private expenditures per year over the estimation interval of 1970 through 2008.

Disposable Personal Income

Income is defined as real per capita disposable personal income (DPI) less Medicaid and Medicare payments.[12]

Real per capita DPI is a highly influential variable in our model of private health spending. The importance of this variable is consistent with a large body of literature examining the empirical relationship between national income and health spending. It has been repeatedly shown that variations in GDP, and thus income, account for the majority of international variation in health spending. A number of studies based on time-series cross-country data for Organization of Economic Cooperation and Development (OECD) economies have largely confirmed the importance of this relationship.[13]

In the NHE Projections Model, income has a lagged effect on health spending. This effect is suggested by several characteristics of the market for health services. The critical element is the role of third-party payers. Since private insurers or public payers account for the large majority of health spending, spending is largely insulated from contemporaneous changes in household income. Furthermore, consumers generally do not pay for most medical expenses directly at the point of purchase. Thus their decisions are not immediately affected in the short term by variations in income except where substantial parts of the expenditure are paid for out-of-pocket.[14] The importance and structure of out-of-pocket cost-sharing varies quite a bit across sectors and over time, and this may affect the lag structure.

Conceptually, the effect of income on private health spending could be affected by the decision to purchase private health insurance. Increases in income, expected health expenditures, or the variance of health expenditures would encourage the purchase of more generous insurance coverage. However, the current-period response is also dampened by the intermediation of employers. Most insurance is purchased through employers, who respond to the pooled interests of their employees. Employers often offer few choices of health plans, and some offer none, limiting short-term flexibility for employees. The introduction of new insurance options in response to employee preferences can be expected to occur with a lag. Negotiating health insurance contracts on an annual basis also causes a delay in the time it takes to respond to changing labor market conditions and employee preferences. In addition, the exercise of control over medical expenses by private insurers may require the development of new organizational structures (for example, variants of managed care or health savings accounts). Such changes may require alternation in government regulation of institutions or in the legal environment. Capital investment in equipment and structures also may be required before access to some medical services can be realized. In each case, several years may be required before a response to changes in income can be fully realized.

Public spending decisions can also be expected to respond to changes in income with a substantial lag. Changes in the growth of public spending will be influenced by the underlying health sector variables that

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[12] The objective is to obtain as nearly as possible a measure of income that applies to the population that accounts for private spending on medical care. Thus we exclude spending for Medicare and Medicaid, which are included in DPI but accrue to a population that is primarily publicly insured. Since private spending includes out-of-pocket and PHI spending for Medicare beneficiaries, the correspondence cannot be exact.

[13] For a review of this literature, see Gerdtham, Ulf, "International Comparisons of Health Expenditure."

[14] Some current period effect can be expected in response to consumer cost-sharing and loss of employment, with the associated loss of employer-provided health insurance.

drive the cost of services and by changes to the regulations that affect the price and volume of these services. Examples include the incentive effects of the physician fee schedule or prospective payment systems. Federal and state level regulation influences the nature of insurance coverage (e.g. diverse forms of "patient protection" legislation), and costs associated with medical malpractice liability. Such changes occur over time as lawmakers respond to perceived problems in the financial status of public programs within the limits of what taxpayers are willing to pay for them.

To capture these potential lags, the income term in our model of personal health care spending is incorporated as a moving average over 5 years (from four years previous through the current period).[15] The relationship between real per capita spending and real per capita DPI is assumed to be log-linear. The assumption of log-linearity implies that prices and income elasticities are constant over time. The income elasticity in our current model is 1.54, near the upper end of estimates for macro-level elasticities of approximately 0.8 to 1.6 in the empirical literature.[16] However, these estimates are generally based on spending by all sources of funding, rather than on private spending alone.

As discussed above, this income term is intended primarily as a proxy for the influence of heterogeneous systemic changes. These developments are assumed to occur in response to changes in incomes within a pool of households, and are the means to adjust health spending for closer consistency with the preferences of this pool (of the insured and of the voting population). These might include changes in the nature and breadth of health insurance coverage offered by employers, the development and evolution of institutional structures for the financing and delivery of medical care (e.g. including the legal environment and organizational structures within the private sector that facilitate the development and diffusion of new forms of coverage like consumer-driven health plans), shifts across different forms of managed care, the passage of state and Federal legislation influencing the costs of providing care, and fluctuations in the fraction of the population with health insurance.[17] The implicit theory underlying this variable is that the income effect occurs indirectly in the form of changes to the institutions within which medical care is provided, rather than at the level of the individual consumer, and that the specific nature of this change cannot be predicted and, almost always, cannot be accurately measured. By the nature of this effect, we can expect some variation in magnitude and timing.

The projection of the income variable is exogenous (an outside input) to our model. Projections of real per capita disposable personal income incorporated in our projections are consistent with exogenous OASDI projections for growth in GDP and the economy-wide personal consumption deflator (see Data Sources section for modeling of link between GDP and DPI). Projections for Medicaid and Medicare spending (subtracted from disposable personal income) are also exogenous, based on OACT projections (see the Data Sources section for a description of all exogenous inputs and source citations).

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[15] Estimates that allow coefficients to vary across this five-year period based on a polynomial distributed lag (PDL) show no statistically significant improvement in explanatory power over a moving average.

[16] Getzen, T.E., "Health Care is an Individual Necessity and a National Luxury: Applying Multilevel Decision Models to the Analysis of Health Care Expenditures," *Journal of Health Economics*, 2, (2000): 259-270.

[17] Explicit measures of managed care based on the inclusion of private sector HMO coverage rates as a proxy for the effects of managed care were found to be insignificant in our model. We believe that this result was associated with problems in the breadth and consistency of the proxy, which does not capture the effects of shifts across forms of managed care over time, changes in the nature of managed care within models of managed care, or spillover effects.

Relative Medical Price Inflation

Economic theory predicts that consumers adjust their spending on different goods and services in response to variations in the relative price of these alternatives. However, the existence of third-party payers for medical care complicates this relationship. Consumers bear only a fraction of the actual price of medical services at the time of purchase. Thus, in short-term consumption decisions, they respond to the marginal out-of-pocket price rather than to the actual price, generally determined by a combination of deductibles, cost-sharing requirements, and out-of-pocket maximums. The price to consumers can theoretically roughly approximated by the fraction of total costs paid out-of-pocket multiplied by the actual price. However, the approximation is very poor; for decision-making purposes the important question is the marginal price, the amount that the consumer pays for an additional dollar of medical care. The broad use of copayments, deductibles, and out-of-pocket maximums, combined with the fact that the majority of health care consumption is accounted for by high-cost cases, means that the marginal price paid by consumers is most often zero. We found that the coefficient on his approximation of relative price to consumers on an out-of-pocket basis was negative (as expected) but statistically insignificant in our aggregate model. This continues to be the case in the most recent estimation.

However, the effects of out-of-pocket prices on consumer choices are only one potential avenue for price effects. Medical prices also influence demand for services in two additional ways. First, the price of health insurance is effectively the price of the bundle of medical goods and services an enrollee is expected to consume (plus administrative costs and profits). Thus, consumers' decision to purchase health insurance, through their employers as agents in most cases, and the amount of health insurance purchased, is influenced by the relative price of medical care through its effect on the price of insurance. Demand for health care, therefore, depends upon changes in the actual relative price of medical care as well as the relative price on an out-of-pocket basis. Second, the relative price of medical care affects demand for services across types of medical care through the price sensitivity of health insurers' coverage and provider selection decisions. The nature of this relationship also suggests the possibility of a lag in the response to relative price of medical consumption compared to the price of all other options for consumption.

Within our model, relative medical price inflation has a significant negative coefficient, as we expect. This year's projection was complicated by the effects of the recent economic crisis on overall consumer prices in 2009. The combination of a severe inventory correction characterized by liquidation of some products, with a downturn in energy prices from a high peak in 2008 resulted in price inflation near zero for all consumption. Meanwhile, medical consumption remained somewhat insulated from the effects of the downturn in aggregate demand due to the role of insurance and an inelasticity of demand for medical care that discouraged price reductions. Medical price trend in 2009 was close to that for 2008, while consumer price inflation fell to an historic low. The result is that relative medical price inflation skyrocketed in 2009, implying an immediate reduction in real spending growth that seemed unrealistically large. The attempt to assess the appropriate effect of this outlier led to a redefinition of the deflator used to define relative medical prices. We now use a centered moving average covering three years to capture the longer-term nature of the substitution effect within the insurance-dominated medical marketplace.

The price elasticity of demand for health care in our updated and revised model is −0.46, (as compared to −0.36 in last year's model). This price elasticity is well above micro-level estimates of price elasticity of

demand for medical care (−0.1 to −0.2 based on the Rand Health Insurance Experiment).[18] This discrepancy reflects the fact that micro-based studies use household-level data on the relationship between consumer out-of-pocket spending below out-of-pocket maximums and effective price given coinsurance rates. In addition to issues associated with the use of aggregated data, such estimates do not include sensitivity to price variation at the point of purchase of insurance, or price sensitivity on the part of insurers and providers acting as agents for consumers. In the absence of a variable to control explicitly for declines in out-of-pocket share, we attempt to adjust for the predicted effects of changes in this variable through judgmental adjustments to the model solution.

Medical price inflation is an endogenous variable in our model (it is determined within the NHE Projections Model). The dependent variable in our model is OACT's price deflator for personal health care spending. This is estimated as a function of a lagged measure of input price inflation for medical goods and services (IPI).[19] Coefficients for lagged IPI are fitted along a linear path over a lag extending from the current year to two years previous. Approximately 60 percent of the effect of changes in input price inflation is estimated to occur within a year. The effects of other factors (economy-wide price inflation, productivity growth, industry profitability) are captured indirectly through their influence on IPI, and through a first-order autocorrelation adjustment.

Our measure of input price inflation is based on the cost structure of health providers as estimated in input price indexes by type of medical providers. The effect of each component of provider costs is represented by a proxy series that is selected to track the input prices of each individual service and commodity. The effects of other factors (economy-wide price inflation, productivity growth, industry profitability) are captured indirectly through their influence on IPI, and through a first-order autocorrelation adjustment. However, due to the limited coverage of the available time-series data available for medical providers, this input price index has historically excluded compensation for self-employed workers, including a substantial fraction of physicians and other medical professionals. Thus, true input price inflation will be under or overstated depending on the growth differential between compensation for employed versus self-employed workers. For this reason, we include growth in physician income in our model as a proxy for supervisory and self-employed provider compensation not covered by our input price indexes. This substantially improves the fit of the model. Our data reveal that physician incomes have been generally growing at a slower pace in comparison with other inputs to medical care since 1992, a finding that fits neatly with a concurrent slowdown in output price inflation relative to our index of input price inflation.

We developed an historical physician income series through 2007 using a weighted index of IRS Statistics of Income (SOI), Bureau of Labor Statistics (BLS), and the Medical Group Management Association (MGMA) data which reasonably tracks physician income historical series from other sources. To project physician income, we used the following model:

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[18] Manning, W.G., et al., "Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment," *American Economic Review*, Vol. 77, No. 3, June 1987.

[19] The input price index used is a weighted average of OACT's input price indexes for hospital services, physician services, home health services, nursing home services, and pharmaceuticals.

Sector	Dependent variable	Independent variables
Physician Income	Real physician income	Real wages and salaries for Professional and Technical (+) Real private physician spending (3 year moving average, lagged 1 year) (+) Real Practice Expenses (−) Dummy, 1994 (−) Dummy, 1995 (+) Dummy, 1998 (−) Dummy, 1997-2019 (−) MA(1) (+)

All of the variables are deflated by the Total Private Wages and Salaries series. The real private physician spending variable is intended to capture approximate changes in volume that are reflected in our measure of physician income, in order to approximate a wage measure. The model also includes growth in real practice expenses, which is assumed to take away from physician income.

Input price inflation (excluding physician income) is an exogenous input to our model. Projections of wage and price proxies that feed into input price indexes are generated by Global Insight Inc., and are adjusted for consistency with OASDI macroeconomic assumptions. Physician income is projected endogenously. Following a decade of decline relative to alternative professional and technical occupations, physician income is assumed to converge with projected income growth for the employment cost index for all professional and technical employees.

Health Spending by Public Payers

In our model of growth in real per capita private spending on PHC, growth in real per capita public spending has a negative coefficient of −0.23. This is unchanged from last year's model. In contrast to coefficients on price and income variables, the coefficient on public spending growth has tended to remain stable as new data has expanded the estimation interval. Public and private sector spending are jointly affected by a number of factors. From the supply side, it is probable that the growth rates in the per enrollee cost of providing treatment to persons insured under public and private programs correspond quite closely in the long term—although demographic and institutional differences will produce some variation.

The negative coefficient on this variable in our model reflects in part that neither public nor private spending is expressed in per enrollee terms. Rather, spending is on a per capita basis—the denominator is total population. The reason for this choice lies in issues with data on insured population (private, Medicare, and Medicaid). The time series for private enrollment is defined to include all persons with private coverage. This including Medigap policies, where the primary source of coverage is Medicare. Thus, there is a substantial overlap between the series. In addition, the history for private enrollment stems from multiple sources and is subject to inconsistencies over time due to variations in survey questions. A second issue is that the history of Medicaid enrollment is volatile, due to changes in eligibility for the program. These changes tend to involve the influx of a relatively low cost per enrollee population (e.g. children and non-disabled adults) relative to the existing Medicaid population (which is relatively heavily weighted towards the institutionalized). This distorts per enrollee growth. The use of

growth on a per capita basis measures means that a shift in enrollment between public and private programs will be associated with a change in per capita spending in the same direction – implying a negative coefficient on public spending in our model.

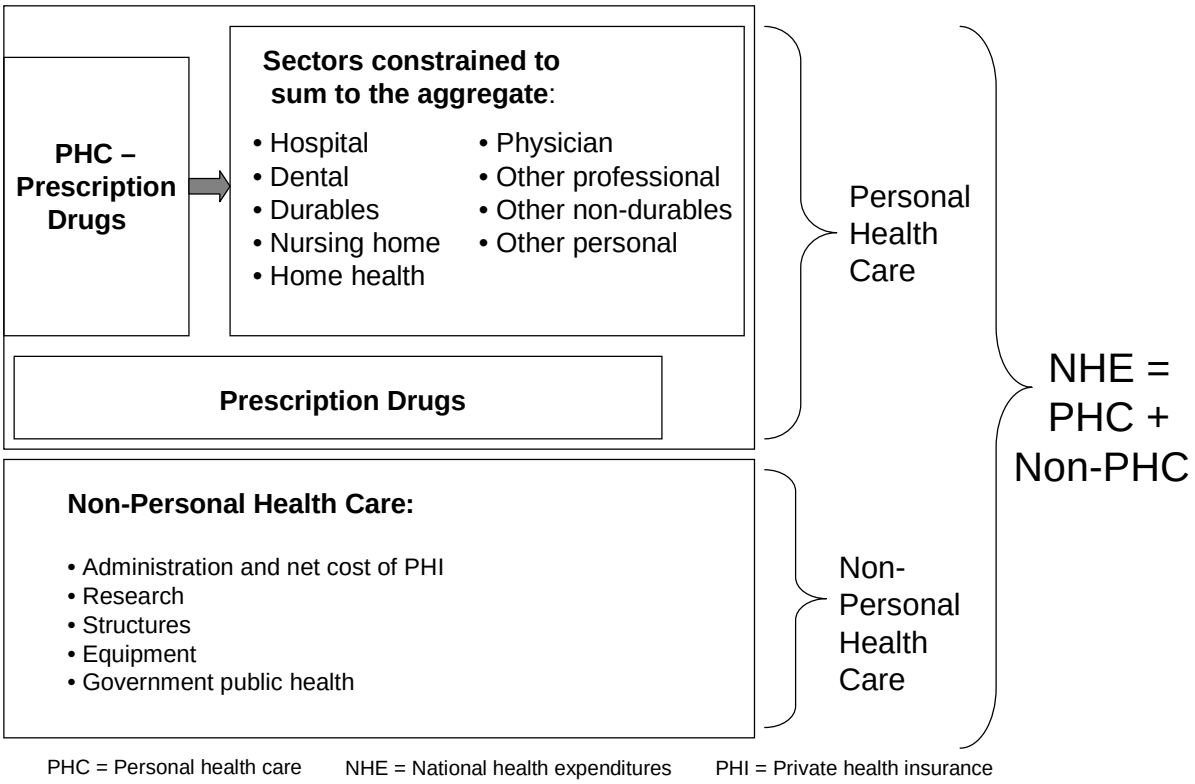
Our model forecasts private spending growth conditional on Medicare and Medicaid spending projections based on the 2009 Trustees Report. We incorporate real per capita public spending as an independent variable in our model of private spending. As discussed above, the balance of the effect of changes in public spending on private spending, after accounting for the shared influence of income, medical price inflation, can be expected to be negative. The negative coefficient on public spending in our regression captures two combined effects over the historical period: (1) shifts in coverage out of private and into public programs, and (2) any potential short-term cost shifting between public and private programs.

Public personal health care spending is largely exogenous to our model—based on actuarial projections of Medicare and Medicaid spending, which account for almost 85 percent of public spending. Medicaid and Medicare spending projections are based on OACT projections. Other public spending is projected endogenously, largely based on current and lagged growth in GDP from OASDI projections (see the Data Sources section for a description of all exogenous inputs to our model and source citations).

III. Types of Services

Models for individual sectors of the NHE Projections Model are discussed below. Sectors are broken into personal health care (PHC) and non-personal health care (Non-PHC) categories.

Sectoral Composition of NHE Projections Model



PHC = Personal health care NHE = National health expenditures PHI = Private health insurance

The aggregate model for personal health care described in the previous section is composed of ten types of services. We use sector-specific equations to establish projections for real per capita spending growth and relative price inflation for each type of service that make up private health care spending. Nine of these sectors are constrained so that the sum of types of services is equal to the model solution for total PHC. The remaining sector, prescription drugs, is not constrained to the aggregate spending total, as we take into account and make adjustments based on insights from a broad range of outside research which cannot be explicitly incorporated in the model. In general, the aggregation of the unconstrained model solution for the sectoral equations results in a total which is close to the aggregate model projection, so that the normalization process does not involve a major adjustment to the patterns of growth for the individual types of services. The non-personal health care components are unconstrained, but account for a much lower share of NHE than the personal health care components.

Real per Capita Spending Growth

Models of real per capita spending growth for the types of services that make up personal health care follow the specification for the aggregate model of PHC. For most sectors, these models have a specification similar to that used for aggregate personal health care. Key structural variables are:

- Disposable personal income growth (less Medicare and Medicaid, real per capita)
- Relative price inflation for the sector
- Public spending growth for the sector (real per capita)

Differences across the models for different types of services are the inclusion of constant terms, varying lag structures for the income effect, the relative importance of the three variables, the inclusion of dummy variables to capture phenomena specific to the sector. In a few cases, the additional independent variables are included where relevant data is available.

Exogenous inputs to these models parallel the aggregate: real per capita disposable income less Medicare and Medicaid, and sector specific projections of Medicare and Medicaid spending.

The lag on the income term generally varies with the share of spending that is accounted for by consumers' out-of-pocket expenses: the greater the out-of-pocket share, the shorter the lag, as consumers respond more quickly to changes in their income. We evaluated coefficients on income and price terms for consistency with the aggregate regression results and across sectors; however, the relationship is not precise.

The table below summarizes the independent variables used to model real per capita spending growth for each of the personal health care sectors. For the sectors with the greatest share of NHE, we have provided some additional descriptive information about their sector models. Only minor changes in specification were made to individual sectoral models, which remain largely unchanged from the models of previous years.

Sector	Dependent variable	Independent variables
Hospital services	Real private hospital services per capita	Real disposable personal income (PDL over 5 years) (+) Relative price(−) Public spending growth (−) Dummy, 1984 (−) Dummy, 1984 * time trend (+) Time trend (−)
Physician services	Real private physician services per capita	Real disposable personal income (4 year moving average, lagged one year) (+) Relative price (−) Real per capita Medicare spending growth (−) Dummy, 1983-85 (+) Dummy, 1993-96 (−)
Other Professional services	Real private other professional services per capita	Constant term Real disposable personal income (+) Real per capita public spending growth (−) Dummy, 1992– (−)
Prescription Drugs	Real aggregate drug spending per capita*	Real disposable personal income (3 year moving average) (+) Relative price * Share paid out-of-pocket (−) New drug introductions (+) Generic dispensing rate (−)
Over the Counter Drugs and Other Nondurables	Real private other nondurables spending per capita	Real disposable personal income (2 year moving average) (+) Relative price (−) Lagged dependent (+)
Durables	Real private durables spending per capita	Real disposable personal income (PDL over 2 years) (+) Relative price (−) Public spending growth (−)
Dental services	Real private dental services per capita	Real disposable personal income (+) Relative price (−) Dummy, 1981 (+)
Nursing home services	Real private nursing home services per capita	Constant term Per enrollee Medicaid spending (+) Public spending (−) Time trend (−) Dummy, 1990 (+) Dummy, 1994 (−) Dummy, 1995 (+) Dummy, 1999 (−)
Home health services	Real private home health services per capita	Medicare spending growth, lag 2 years (+) Medicaid spending growth (−) Dummy, 1988 (+) Dummy, 1998 (+)

*The prescription drug model is based on aggregate expenditures rather than private expenditures, due to complications in projecting shifts in payments predicted associated with the introduction of Medicare's Part D prescription drug coverage. See the Prescription Drug section below.

Hospital Services

Real per capita growth in private hospital spending is well explained by the variables in our template model specification. Given the low out-of-pocket share on average for hospital services (inpatient and outpatient), we anticipate a long lag between a change in household income and the time of impact on hospital spending. Our results are consistent with this expectation we estimate coefficients on lagged income growth with a polynomial distributed lag, which indicates the peak effect of income fluctuations occurs with a lag of 3 to 4 years.

Attempts to fit an out-of-pocket variable, either in combination with the price term (i.e. effective price to consumers) or separately, were unsuccessful. However, in the hospital sector, this share is low and fairly stable (just over 3 percent for 1995 through 2003) so effects are likely to be small.

Public real per capita spending has a negative coefficient as expected, capturing shifts in enrollment between private and public coverage, as well as any short-term cost-shifting effects between private and public payers.

Our current model for real per capita growth in hospital spending does not include an explicit effect for managed care. Managed care is expected to continue to influence growth in hospital spending through both utilization and relative price inflation. However, we have found that our previous proxy for managed care effects to be increasingly flawed for this purpose. The combined effect of managed care and the Medicare prospective payment system (PPS) for this sector is represented in the current model as a structural change in the relationship of growth to price and income variables that is largely one-time in nature, beginning after the introduction of PPS (from 1984). The alterations in provider incentives associated with the change in provider incentives inherent in PPS and similar pressures from the expansion of managed care in the late 1980s through the 1990s produced an initial reduction in growth that tapers off gradually over time. This reflects diminishing potential for additional reductions in inpatient utilization over time.

Physician Services

The estimated lag structure for the income term in the physician model indicates an effect which extends over four years, but is evenly weighted across periods (effectively a shorter average lag as compared with the hospital model). The sum of coefficients on all lags of the income term is substantially smaller than for the hospital sector, close to the coefficient in the aggregate model for PHC. Relative price inflation fits only weakly in this model as compared with PHC, and growth in real per capita public spending on physician services has a smaller estimated negative effect than the aggregate model.

In general, our template specification fits real per capita growth in physician spending somewhat less well than hospital spending. This primarily reflects two outlying periods: much higher than predicted growth in 1984 and 1985 and much lower than predicted growth in 1993 through 1996. Absent these periods, the pattern of growth implied by the income and relative price term produces a fairly good fit. Through 1983, the physician share of personal health care spending remains close to flat, drifting slightly downwards (from 24.0 percent in 1965 to 22.0 percent in 1983). From 1984 through 1994, the share rises, reaching 26.0 percent by 1992 before beginning to move downwards to 25.3 percent by 2001. Without some

control for the period of rapid growth in the early 1980s, it is difficult to obtain a model with acceptable fit and reasonable coefficients.

We have included a dummy variable to capture the period of rapid growth from 1983 through 1985, while the faster growth later in the decade is consistent with the income term. Our interpretation of this variable is that it captures a non-recurring substitution effect of professional services for inpatient care. This period saw a major shift in provider incentives associated with the introduction of inpatient PPS under Medicare (spillover effects for private spending) and the initial surge in managed care enrollments. In this sense this pattern of growth is a counterpart of the changes in inpatient utilization generated by these developments. The effect of the inclusion of this dummy is that the resulting model will tend to project a pattern of growth for physician services that is more consistent with the near-stable share of PHC in the pre-1984 and post-1994 data rather than the more rapid growth of the mid-1980s.

Prescription Drugs

Prescription drugs differ in important ways from other types of medical care. First, it is a product, not a service, so the cost structure of the industry differs substantially from sectors such as hospital, physician, or nursing home, where labor costs play a critical role in driving price. Second, historically, prescription drug spending has had a much larger consumer out-of-pocket share than other types of medical care, so that demand tends to be more sensitive to price. Third, the public sector has historically played a relatively small role in funding prescription drug spending. We also have access to additional information on supply and demand factors for this sector, in the form of data on new drug introductions, generic dispensing rates, research spending, patent expirations, and direct-to-consumer (DTC) advertising. As a result, our model for prescription drugs is somewhat different from those developed for other sectors.

As opposed to the other sectors, the dependent variable in the prescription drug model is real aggregate per capita drug spending (not private only). This change was made because the start of Medicare drug coverage in 2006 produced a massive shift in the source of payments for drugs, resulting in a sharp drop in private drug spending growth in 2006, but otherwise had little estimated effect of overall growth in drug spending. Therefore, our model projects total prescription drug spending without simulating an explicit effect for Part D. We use data from the President's FY 2010 Budget to adjust the projections to incorporate the effects of Medicare drug coverage and to produce forecasts for private, Medicaid, and Medicare spending that are consistent with actuarial estimates of the magnitude of the shift in spending due to Part D.

Our income variable fits with a shorter lag than in our aggregate model. This is the expected result based on the larger share paid on an out-of-pocket basis historically. Relative price inflation has a strong fit. A recent change to this model was the redefinition of the price variable as the product of the out-of-pocket prescription drug share and the prescription drug price index. This change is intended as a conceptual change to account for the fact that consumers' out-of-pocket share has declined steadily over the last twenty years. However, the fact that available data does not distinguish out-of-pocket spending by the uninsured and by Medicare beneficiaries from the fixed co-payments often required within managed care limits our ability to capture this effect. Public spending growth is not included as a variable in this model due to its relatively minor role.

Patterns of growth over the most recent ten years of data are by far the most difficult to explain as the effects of several different factors must be disentangled. The out-of-pocket share of spending by consumers dropped sharply as privately insured patients moved into managed care plans that generally

have lower co-payments (this phenomenon largely did not apply to Medicare beneficiaries, who continued to pay a relatively large share of drug costs out-of-pocket). Also, changes to regulations in 1997 dropped some of the earlier restrictions on television advertising for prescription drugs. In addition to income and relative price terms, our model for real per capita drug spending includes a four-year moving average of the number of new prescription drugs introduced. In addition, the rising generic dispensing rate, which has played an increasing role in depressing growth in prescription drug spending in recent years, is now included in our model. We have adjusted the drug price model downward in 2012 and 2013 to reflect the impact of a large number of top-selling brand-name prescription drugs losing their patent protection in 2011 and 2012. Large price declines for individual drugs do not typically occur until about 6 months after the patent expires; therefore, the main effect on price in the annual numbers is usually seen the year after patent expiration.

Relative Price Inflation by Type of Service

Price inflation for individual types of services was initially modeled based on relative input prices. However, we were unable to obtain theoretically consistent and significant results, probably due to flaws in discrepancies in definition and flaws in measurement of both the output price and input price indexes.

Our current model explains variations in sectoral price inflation relative to personal health care (which is in turn driven by projections of input price inflation). Changes in public policy that could be expected to influence relative prices differentially across NHEA sectors (such as the imposition of price controls in the early 1970s and the introduction of the prospective payment system for Medicare hospital inpatient services in 1983) are captured through the use of dummy variables. Our managed care proxy was also included in selected models (hospital, dental) since the effect of selective contracting has differing effects on price inflation for different medical services.

Variables included in models of relative price inflation are shown in the table below:

Sector	Dependent variable	Independent variables
Hospital services	Hospital price inflation (relative to all medical services)	HMO Penetration, level (PDL over 2 years) (−) Relative growth in hospital compensation rates (+)
Physician services	Physician services price inflation (relative to all medical services)	Constant (+) Real Physician income growth (+) AR (1)
Other Professional Services	Other professional services price inflation (relative to all medical services)	Physician price inflation (+) Autoregressive error term (+)
Prescription Drugs	Drug price inflation (relative to economy-wide)	Relative input price inflation, lagged one year (−) Growth in drug research spending (PDL over 4 years) (+) Dummy, 1993 forward (−)
Dental services	Dental price inflation (relative to all medical services)	Medical Services price growth (−) Dummy, 1976 (−) Dummy, price controls, 1973 to 1974 (−) Dummy, 1981 to 1985 (−) Autoregressive error term (+)
Nursing home services*	Nursing home price inflation	Nursing home input price inflation
Home health services	Home health price inflation	PHC price inflation growth (+) Autoregressive error term (+)

* Projection for nursing home input price inflation is adjusted from projections by Global Insight, Inc. for consistency with SSA projections of economy-wide inflation.

Generally, it proved more difficult to achieve a good fit for the relative price regressions for individual sectors than for the real per capita spending regressions. This reflects the combination of flaws and inconsistencies in the price data, and the difficulty in capturing the effects of government policy and institutional change on relative price across types of services. For example, managed care can be expected to influence prices in some sectors (e.g. hospital services) much more than others (dental services), with potentially important effects on relative price inflation for these sectors, but our proxy for capturing managed care effects is flawed. Dummy variables, are, of course, an imperfect tool for capturing effects of government policy which has effects on relative price (e.g. price controls).

Note, however, that where the regression fit for relative price inflation is not good (e.g. physician services) the resulting equation will generate a forecast which tends to track the price inflation forecast for the denominator, which often accounts for a very high fraction of variation.

IV. Sources of Funding

Econometric models for change in the composition of private spending across sources of funds (private health insurance, out-of-pocket, and other private) represent an attempt to systematically extrapolate patterns in sources of payment that can be found in the historical data.

This year's model incorporates two major changes to the structure of the models used to project spending by these sources of funds. First, the dependent variables in the new model are real per capita growth rates for each source of funds. This contrasts with the previous model, which explained changes in the share of (for example) out-of-pocket spending relative to total spending for each sector, allowing one source of funds (private health insurance) to be determined as a residual. It is an advantage of the new model that no category is treated as a residual; all are modeled and adjusted directly. However, this structure also implies that the forecast generated will not be consistent with the total generated for private and public spending aggregates at a higher stage of the model. To maintain consistency with total expenditures across two dimensions (type of service and source of funds) we use iterative proportional fitting to adjust the matrix of spending across these dimensions for consistency with both.

The independent variables that influence growth by source of funds in the newly specified model are similar to those incorporated in the previous specification. Trends in insurance coverage (private, Medicaid, and Medicare enrollment, and the uninsured population) influence the composition of private spending by payer, since the fraction paid out of pocket differs substantially across these groups. Shifts in enrollment can be expected to have an effect that varies across sectors – the most prominent example being prescription drugs. Changes such as the historical spread of managed care (with the associated pattern of much lower co-payments) can also be helpful in explaining historical patterns of growth across sources of funds. In addition, current period growth in disposable personal income may have an impact on the relative pace of growth in out-of-pocket spending through its influence on discretionary medical spending.

The second major change in our sources of funds model is that the model is now clearly "bottom-up" in nature. This means that the forecast for aggregate spending for private health insurance, for example, is determined by the sum across types of services. While we do generate an initial projection each source of funds at the aggregate level, this projection is used only as a rough guide and does not constrain projections for the types of service. The advantage of the "bottom-up" approach is that aggregation can obscure relevant trends that apply to specific types of services, and make it more difficult to adjust projections precisely at the level where information is most available. For example, trends in OOP for prescription drugs have leveled out since 2001 as the magnitude and structure of out-of-pocket cost-sharing has increasingly been used to guide consumers towards more cost-effective alternatives and to reduce incentives for excessive use. Prescription drugs, physician services, nursing home care, and dental services account for about two-thirds of out-of-pocket spending, but are driven by a different mix of factors. In addition, since OOP share differs markedly across sectors, shifts between sectors (for example, hospital to drug spending) will have important effects on aggregate trends. It is easier to capture the effect of sectoral shifts by summation than econometrically at the aggregate level.

As mentioned above, private health insurance spending is now determined as a function of the same variables that influence other sources of funds, rather than as a residual remaining after projecting out-of-pocket and other private spending. The primary advantage is that private health insurance spending may now be adjusted directly rather than through changes to other sources of funds.

An exception to this model specification is prescription drug spending. The projections for the out-of-pocket share of prescription drug spending are exogenous to the model. This reflects the relatively large amount of data that is available for this sector, which is largely in anecdotal form, rather than as consistent time-series data that might be easily incorporated in an econometric model.

The projections produced by these models are then adjusted based on an evaluation of the model fit and (where available) on additional sources of information (for example, survey results with information on the nature of out-of-pocket payments for employer-provided health coverage).

In addition to our model of private sources of funds, we also project sources of public funds other than Medicare and Medicaid. These sources account for approximately 25 percent of total public spending. Other federal and other state and local spending (exclusive of Medicare and Medicaid spending) are projected based on econometric models similar to those used to project real per capita private spending models. Like our models for private spending, we specify aggregate PHC spending for other federal and other state and local, and then establish sector-level spending within the constraint of the aggregate projection.

Our projection process combines to give us a sound and defensible projection methodology based on accepted econometric and actuarial projection techniques. As with any projection, we are constantly reviewing the accuracy of our projections and working to make improvements in the methodology. Please e-mail DNHS@cms.hhs.gov with any comments, feedback, or suggestions on our NHE Projection Model.